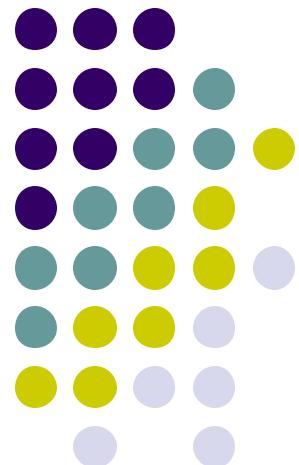


# Updated J&E Model VIAModel.xls

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Helen Dawson, Ph.D.  
USEPA Region 8





# What's Different?

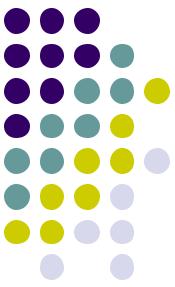
---

- Combines screening and advanced versions of the groundwater and soil gas spreadsheets.
- Provides default parameters for commercial buildings and commercial exposure scenarios.
- Incorporates reasonableness checks based on Johnson (2002).



# What's Different, Cont'd?

- Makes transparent the intermediate fate and transport calculations.
- Provides both forward and reverse calculations:
  - Soil gas and/or groundwater screening level concentrations
  - Indoor air concentration estimate and corresponding cancer risk and/or hazard quotient
- Provides an estimate of subsurface soil gas profile under building.
- Incorporates uncertainty calculations
- Provides results for multiple chemicals



# What Hasn't Changed

---

- Same basic J&E (1991) algorithm
- Same conceptual assumptions



# Intended Applications?

- **Constrained** applications:

- Conservative screening based on exterior data
- No interior sampling needed

- **Calibrated** applications:

- Site-specific assessments
- Interior samples for comparison



# J&E Model Input

---

- Constrained model input parameters
  - Source characteristics
  - Building characteristics
  - Vadose zone characteristics
  - Exposure parameters



# J&E Model Input

- Constrained application:

US EPA VAPOR INTRUSION ASSESSMENT MODEL (VIA_MODEL.xls)						
Site Name:						
Parameter	Units	Symbol	Value	Default	Flag	Comment
<b>Source Characteristics:</b>						
Source medium		Source	Groundwater			
Groundwater concentration	(ug/L)	Cmedium	100			
Depth below grade to water table	(m)	Ls	3.00			
Average groundwater temperature	(°C)	Ts	15		/	
<b>Chemical:</b>						
Chemical Name		Chem	Tetrachloroethylene			
<b>Building Characteristics:</b>						
Building setting		Bldg_Setting	Residential			
Foundation type		Found_Type	Basement w/ slab			
<b>Vadose zone characteristics:</b>						
<u>Stratum A (Top of soil profile):</u>						
Stratum A SCS soil type		SCS_A	Sand			
Stratum A thickness (from surface)	(m)	hSA	3.00			
<u>Stratum B (Soil layer below Stratum A):</u>						
Stratum B SCS soil type		SCS_B	Not Present			
Stratum B thickness	(m)	hSB				
<u>Stratum C (Soil layer below Stratum B):</u>						
Stratum C SCS soil type		SCS_C	Not Present			
Stratum C thickness	(m)	hSC				
<b>Exposure Parameters:</b>						
Target risk for carcinogens	(-)	Target_CR	1.00E-06			
Target hazard quotient for non-carcinogens	(-)	Target_HQ	1		/	



# J&E Model Input

## Source Characteristics

- **Vapor source medium**
  - groundwater or soil gas
  - not bulk soil
- **Source medium concentration**
  - If groundwater: check < aqueous solubility for groundwater
  - If soil gas: check < saturated vapor conc. for soil gas\*
- **Depth to source**
  - If groundwater: depth to water table
  - If soil gas: depth to sample
- **Average subsurface temperature**



# Source Characteristics

## Source Characteristics:

Source medium		Source	Groundwater	<input type="button" value="▼"/>
Groundwater concentration	(ug/L)	C <sub>medium</sub>	100	
Depth below grade to water table	(m)	L <sub>s</sub>	3.00	
Average groundwater temperature	(°C)	T <sub>s</sub>	15	
Calc: Source vapor concentration	(ug/m <sup>3</sup> )	C <sub>s</sub>	44484	

## Source Characteristics:

Source medium		Source	Soil Gas	<input type="button" value="▼"/>
Soil vapor concentration	(ug/m <sup>3</sup> )	C <sub>medium</sub>	100	
Depth below grade to soil gas sample	(m)	L <sub>s</sub>	3.00	
Average vadose zone temperature	(°C)	T <sub>s</sub>	15	
Calc: Source vapor concentration	(ug/m <sup>3</sup> )	C <sub>s</sub>	100	

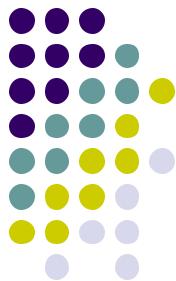


# J&E Model Input

# Building Characteristics

- Building setting
  - Residential
  - Commercial/industrial
- Foundation type
  - Basement w/ slab
  - Basement w/ dirt floor
  - Crawlspace w/ slab
  - Crawlspace w/ dirt floor
  - Slab-on-grade

# Residential Building Parameters



## Building Characteristics:

<b>Building setting</b>		Bldg_Setting	Residential	
<b>Foundation type</b>		Found_Type	Basement w/ slab	
Depth below grade to base of foundation	(m)	Lb	2.00	
Foundation thickness	(m)	Lf	0.10	
Fraction of foundation area with cracks	(-)	eta	1.00E-03	
Enclosed space floor area	(m <sup>2</sup> )	Ab	150	
Enclosed space mixing height	(m)	Hb	3.66	
Indoor air exchange rate	(l/hr)	ach	0.50	
Qsoil/Qbuilding	(-)	Qsoil_Qb	0.0200	
Calc: Building ventilation rate	(m <sup>3</sup> /hr)	Qb	274.50	
Calc: Average vapor flow rate into building	(m <sup>3</sup> /hr)	Qsoil	5.49	

For Tier 3, default parameters for residential buildings should not be changed.

# Commercial Building Parameters



Building Characteristics:				
Building setting	Bldg_Setting	Commercial	Commercial	
Foundation type	Found_Type	Slab-on-grade	Slab-on-grade	
Depth below grade to base of foundation	(m)	Lb	0.20	0.20
Foundation thickness	(m)	Lf	0.20	0.20
Fraction of foundation area with cracks	(-)	eta	1.00E-03	1.00E-03
Enclosed space floor area	(m <sup>2</sup> )	Ab	500	500
Enclosed space mixing height	(m)	Hb	3.00	3.00
Indoor air exchange rate	(1/hr)	ach	3.00	1.00 <span style="color:red;">WARNING: Value is outside of reasonable range (0.2 - 2).</span>
Qsoil/Qbuilding	(-)	Qsoil_Qb	0.0007	0.002
Calc: Building ventilation rate	(m <sup>3</sup> /hr)	Qb	4500.00	1500.00
Calc: Average vapor flow rate into building	(m <sup>3</sup> /hr)	Qsoil	3.00	3.00

For Tier 3, default parameters for residential buildings may be changed.



# Building Data Table

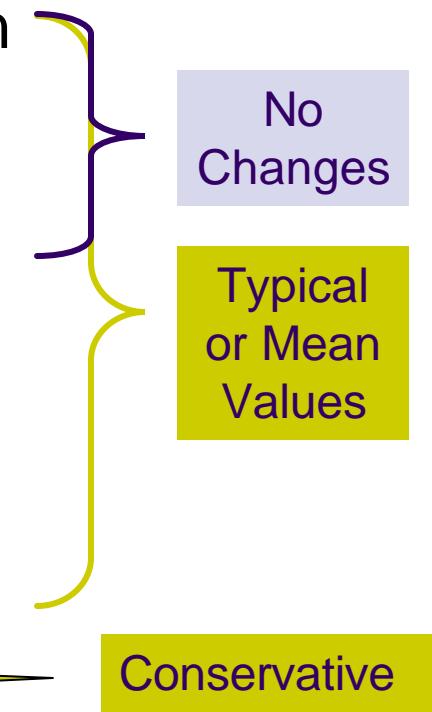
\ README \ MODEL \ SOIL\_DATA \ CHEM\_DATA \ BLDG\_DATA \ EXPOSURE\_DATA \

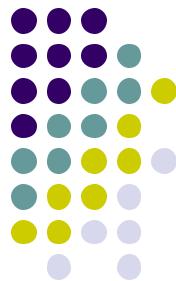
Setting	Foundation type	Depth Below Grade to Base of Foundation		Fraction of foundation area with cracks	Enclosed Space Area	Enclosed Space Height	Indoor Air Exchange Rate	Building Ventilation Rate	Qsoil/Qbuilding
		Lb (m)	Thickness Lcrack (m)						
Commercial	Basement w/ slab	2	0.2	0.001	500	4	1	2000	0.0020
Commercial	Basement w/ dirt floor	2	0	1	500	4	1	2000	0.0020
Commercial	Crawlspace w/ slab	1	0.2	0.001	500	3.50	1	1750	0.0020
Commercial	Crawlspace w/ dirt floor	1	0	1	500	3.50	1	1750	0.0020
Commercial	Slab-on-grade	0.2	0.2	0.001	500	3.00	1	1500	0.0020
Residential	Basement w/ slab	2	0.1	0.001	150	3.66	0.5	274.5	0.020
Residential	Basement w/ dirt floor	2	0	1	150	3.66	0.5	274.5	0.020
Residential	Crawlspace w/ slab	1	0.1	0.001	150	3.00	0.5	225.0	0.020
Residential	Crawlspace w/ dirt floor	1	0	1	150	3.00	0.5	225.0	0.020
Residential	Slab-on-grade	0.1	0.1	0.001	150	2.44	0.5	183.0	0.020

# Residential Default Building Parameters



- Depth below grade to base of foundation
- Foundation thickness
- Enclosed space mixing height
- Fraction of foundation area with cracks
- Enclosed space floor area
- Indoor air exchange rate
- Qsoil





# J&E Model Input

## Vadose Zone Characteristics

- Up to three soil layers
- 12 SCS soil types
- Default parameters (typical or mean values):
  - Total porosity
  - Water-filled porosity
  - Bulk density

SCS Soil Name	SCS Symbol	Total porosity n (cm <sup>3</sup> /cm <sup>3</sup> )	Water-filled porosity nw (cm <sup>3</sup> /cm <sup>3</sup> )	Bulk Density rho (g/cm <sup>3</sup> )
Not Present				
Clay	C	0.459	0.215	1.43
Clay Loam	CL	0.442	0.168	1.48
Loam	L	0.399	0.148	1.59
Loamy Sand	LS	0.390	0.076	1.62
Sand	S	0.375	0.054	1.66
Sandy Clay	SC	0.385	0.197	1.63
Sandy Clay Loam	SCL	0.384	0.146	1.63
Sandy Loam	SL	0.387	0.103	1.62
Silt	SI	0.489	0.167	1.35
Silt Loam	SIL	0.439	0.18	1.49
Silty Clay	SIC	0.481	0.216	1.38
Silty Clay Loam	SICL	0.482	0.198	1.37



# J&E Model Input

## Risk & Exposure Parameters

- Target risk for carcinogens
- Target hazard quotient for non-carcinogens
- Exposure scenario (tied to building type)
  - Default Values:

**Added**

Exposure Parameter		Scenario	Residential	Commercial
Averaging time for carcinogens	(yrs)	ATc	70	70
Averaging time for non-carcinogens	(yrs)	ATnc	30	25
Exposure duration	(yrs)	ED	30	25
Exposure frequency	(days/yr)	EF	350	250
Exposure time	(hrs/24 hrs)	ET	24	8



# J&E Model Output

---

- Attenuation factor
- Predicted indoor air concentration
- Critical parameters
- Risk based target screening levels
- Incremental risk estimates
- Soil gas profile\*
- Uncertainty estimate\*
  - Propagation of error (coefficient of variation)

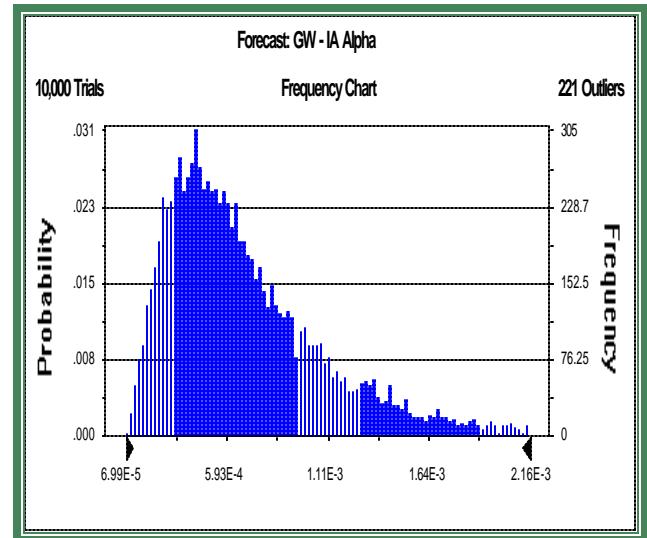
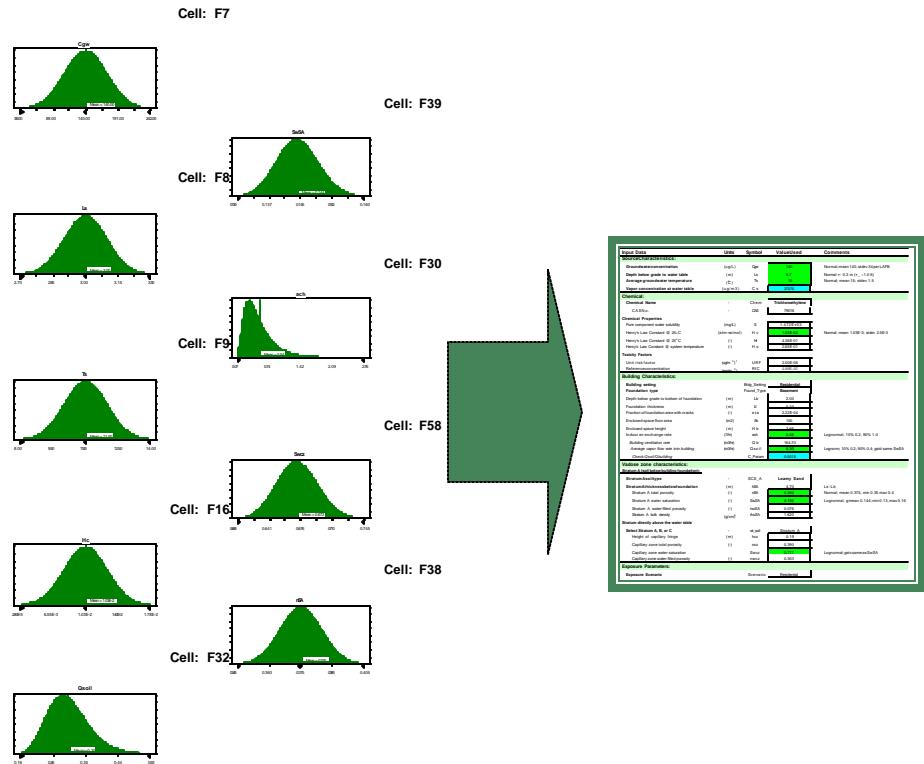


# J&E Model Output

Fate and Transport Calculations	Units	Symbol	Value	Default
<b>Source to Indoor Air Attenuation Factor</b>				
Ground water to indoor air attenuation coefficient	(-)	alpha	7.13E-04	7.13E-04
<b>Predicted Indoor Air Concentration</b>				
Indoor air concentration due to vapor intrusion	(ug/m3)	Cia	3.17E+01	3.17E+01
<b>Critical Parameters</b>				
alpha for diffusive transport from source to building with dirt floor foundation	(-)	A_Param	7.39E-04	7.39E-04
Pe for transport through the foundation (advection / diffusion)	(-)	B_Param	5.28E+02	5.28E+02
alpha for convective transport from subslab to building	(-)	C_Param	2.00E-02	2.00E-02
<b>Critical Parameters</b>				
Hb, Ls, DeffT, ach				
<b>Non-Critical Parameters</b>				
Qsoil_Qb, Lf, DeffA, eta				
<b>Risk Calculations</b>				
<b>Risk-Based Target Screening Levels</b>				
Target risk for carcinogens	(-)	Target_CR	1.00E-06	1.00E-06
Target hazard quotient for noncarcinogens	(-)	Target_HQ	1	1
<b>Target indoor air concentration</b>				
Target groundwater concentration	(ug/m3)	Target_IA	4.12E-01	4.12E-01
<b>Target groundwater concentration</b>				
Target groundwater concentration	(ug/L)	Target_GW	1.30E+00	1.30E+00
<b>Incremental Risk Estimates</b>				
Incremental cancer risk from vapor intrusion	(-)		7.69E-05	7.69E-05
Hazard quotient from vapor intrusion	(-)		5.07E-02	5.07E-02

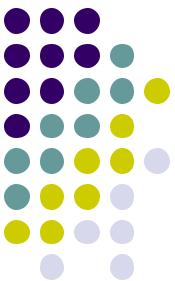


# Uncertainty Analysis



INPUT PARAMETERS

ATTENUATION FACTOR



# Uncertainty Estimate

---

- Coefficient of variation assigned to each input parameter
- Propagation of error
- Estimate coefficient of variation for each predicted output parameter



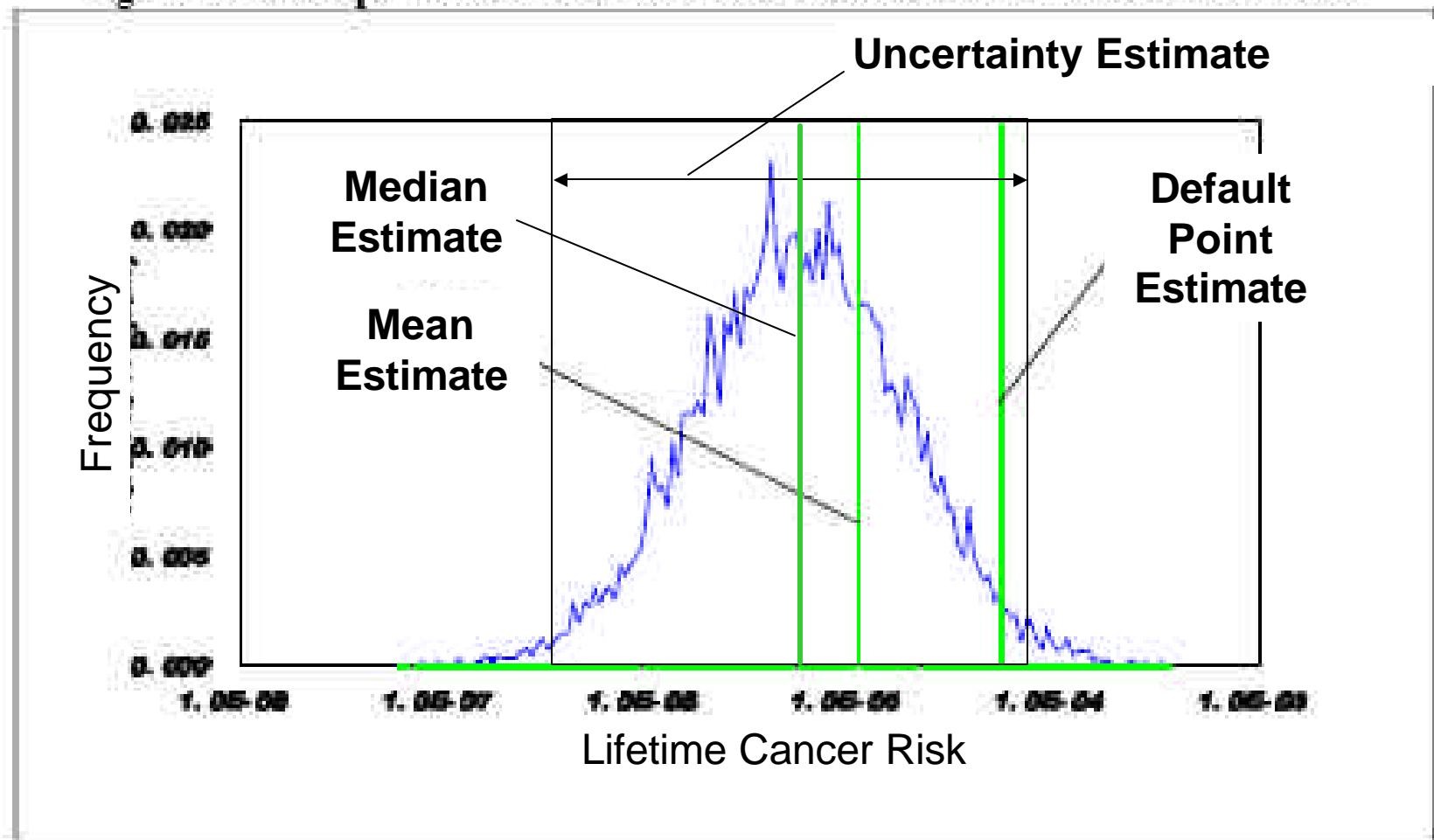
# Uncertainty Analysis Input

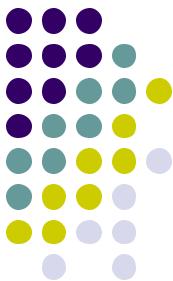
Note: Cells with borders indicate parameters that may be varied.							
Parameter	Units	Symbol	Value	Default	CV	Range	
<b>Building Characteristics:</b>							
Building setting		Bldg_Setting	Residential	Residential			
Foundation type		Found_Type	Basement w/ slab	Basement w/ slab			
Depth below grade to base of foundation	(m)	Lb	2.00	2.00			
Foundation thickness	(m)	Lf	0.10	0.10			
Fraction of foundation area with cracks	(-)	eta	1.00E-03	1.00E-03			
Enclosed space floor area	(m <sup>2</sup> )	Ab	150	150			
Enclosed space mixing height	(m)	Hb	3.66	3.66			
Indoor air exchange rate	(l/hr)	ach	0.50	0.50	1.0	0.1 - 2.0	
Qsoil/Qbuilding	(-)	Qsoil_Qb	0.020	0.020	1.2	0.0003 - 0.02	
Calc: Building ventilation rate	(m <sup>3</sup> /hr)	Qb	274.50	274.50			
Calc: Average vapor flow rate into building	(m <sup>3</sup> /hr)	Qsoil	5.49	5.49			
<b>Vadose zone characteristics:</b>							
<b>Stratum A (Top of soil profile):</b>							
Stratum A SCS soil type		SCS_A	Sand				
Stratum A thickness (from surface)	(m)	hSA	3.00				
Stratum A total porosity	(-)	nSA	0.375	0.375	0.3		
Stratum A water-filled porosity	(-)	nwSA	0.054	0.054	1.0		
Stratum A bulk density	(g/cm <sup>3</sup> )	rhoSA	1.660	1.660	0.2		



# Uncertainty Analysis Output

**Figure 1a.** Example Monte Carlo Estimate of the PDF for Lifetime Cancer Risk





# Vapor Intrusion FAQs

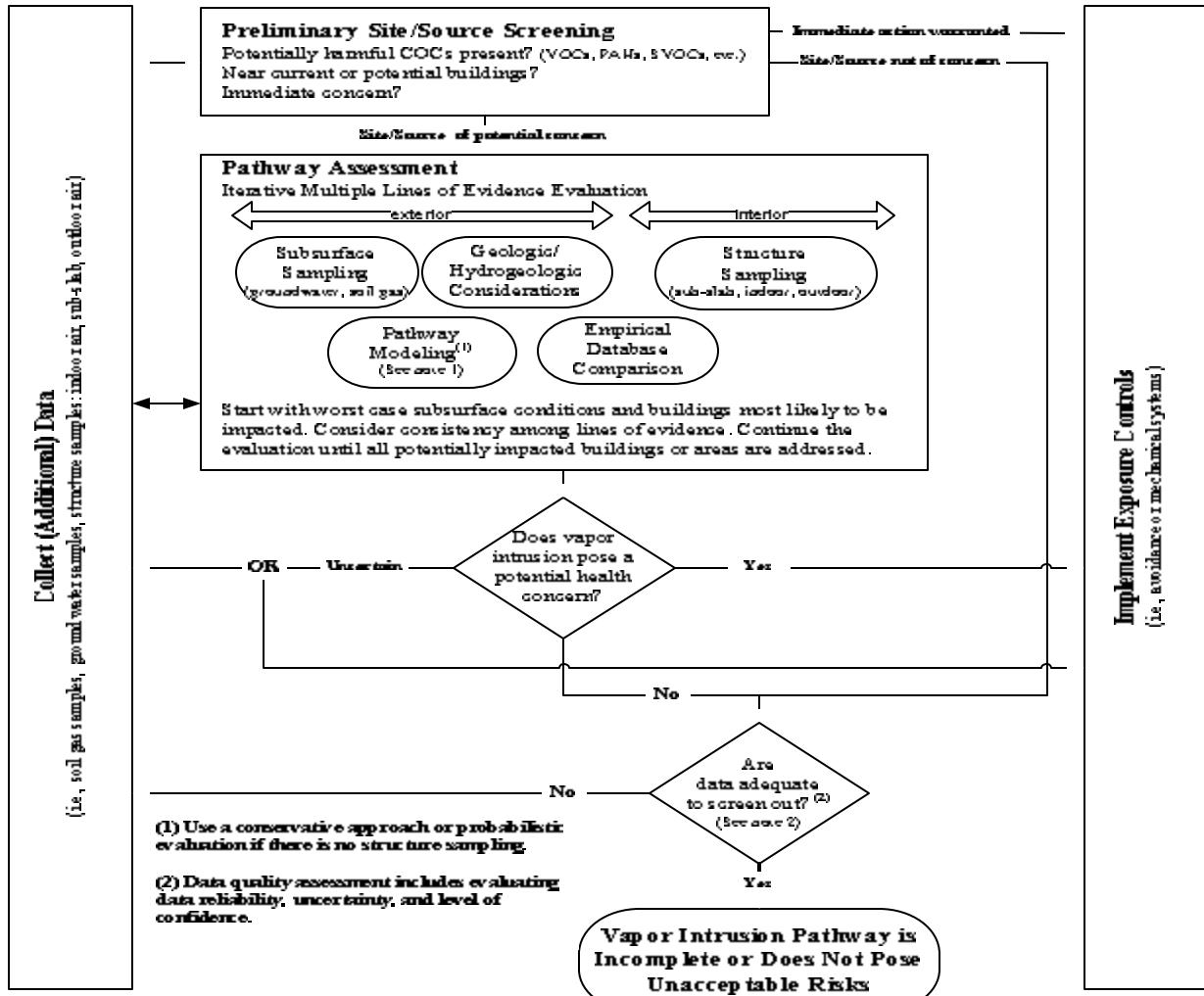
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- When should modeling be done?
- What if modeling results and indoor air measurements don't agree?
- What if modeling results based on groundwater data and soil gas data don't agree?
- Can I use bulk soil data?
- What concentration to input?



# When should modeling be done?

# Multiple Lines of Evidence Approach





# What if modeling results and indoor air measurements don't agree?

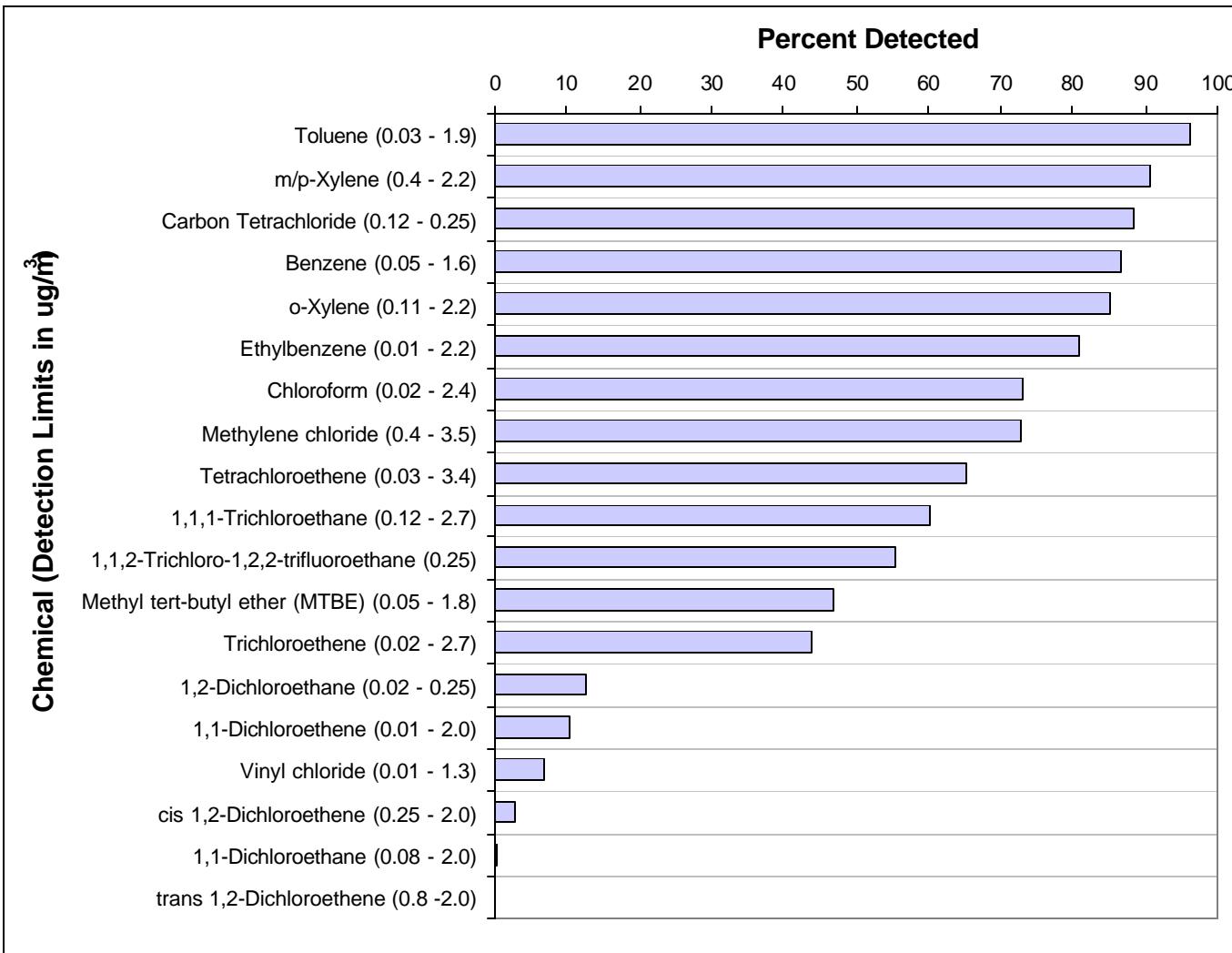
- Geology/stratigraphy
  - Enhanced transport (fractures; very coarse-grained materials; open sumps)
  - Decreased transport (fine, moist layers; vapor barriers)
- Degradation
- Sample representativeness
  - Spatial and temporal variability
  - Sampling error
- Building ventilation
- Background
  - Compare background levels
  - Compare compound ratios



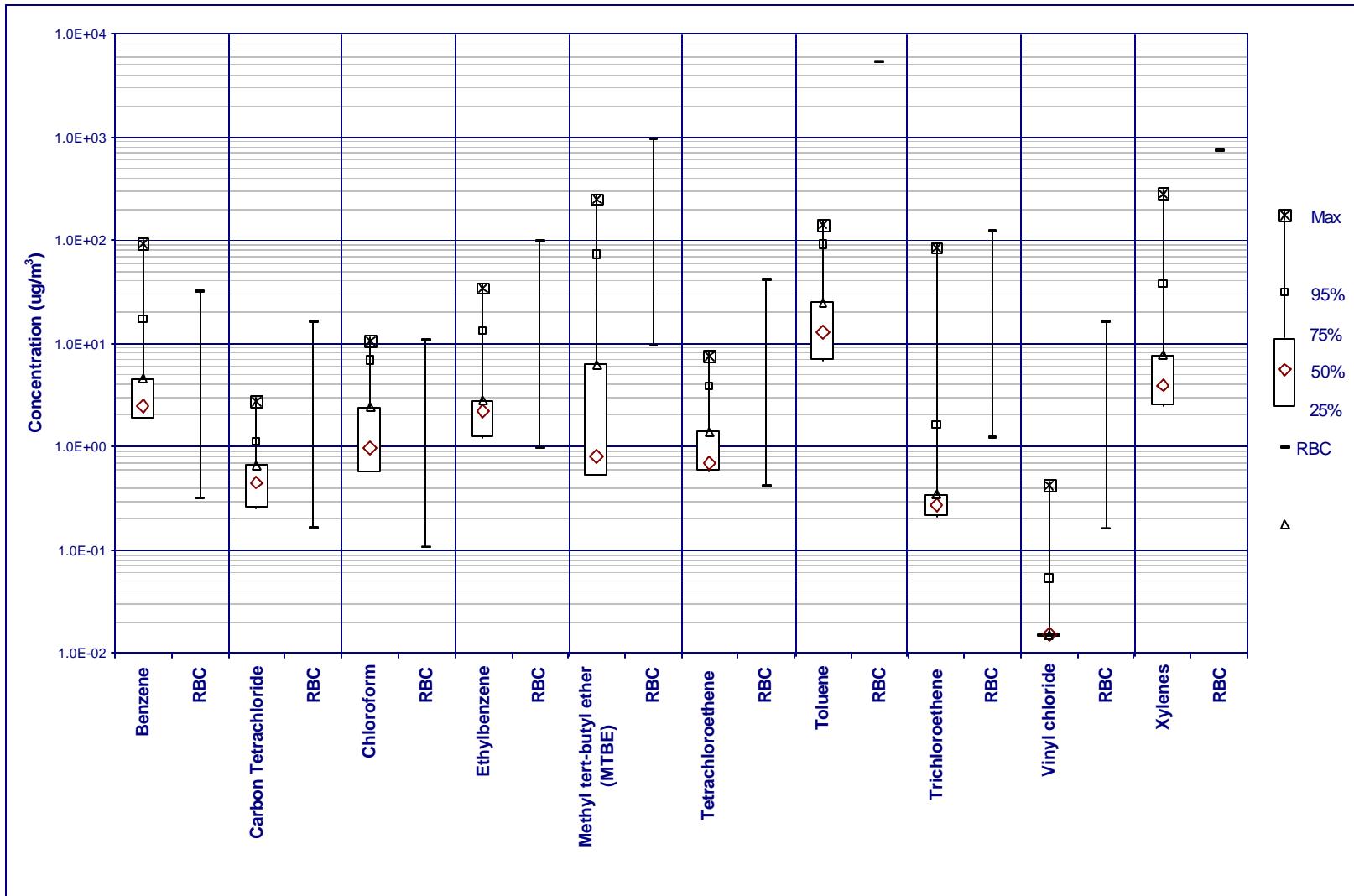
# What if modeling results and indoor air measurements don't agree?

- **Background**
  - Compare background levels
  - Compare compound ratios
- **Sample representativeness**
  - Spatial and temporal variability
  - Sampling error
- **Model input parameters**
- Geology/stratigraphy
  - Enhanced transport (fractures; very coarse-grained materials; open sumps)
  - Decreased transport (fine, moist layers; vapor barriers)
- Degradation
- Building ventilation

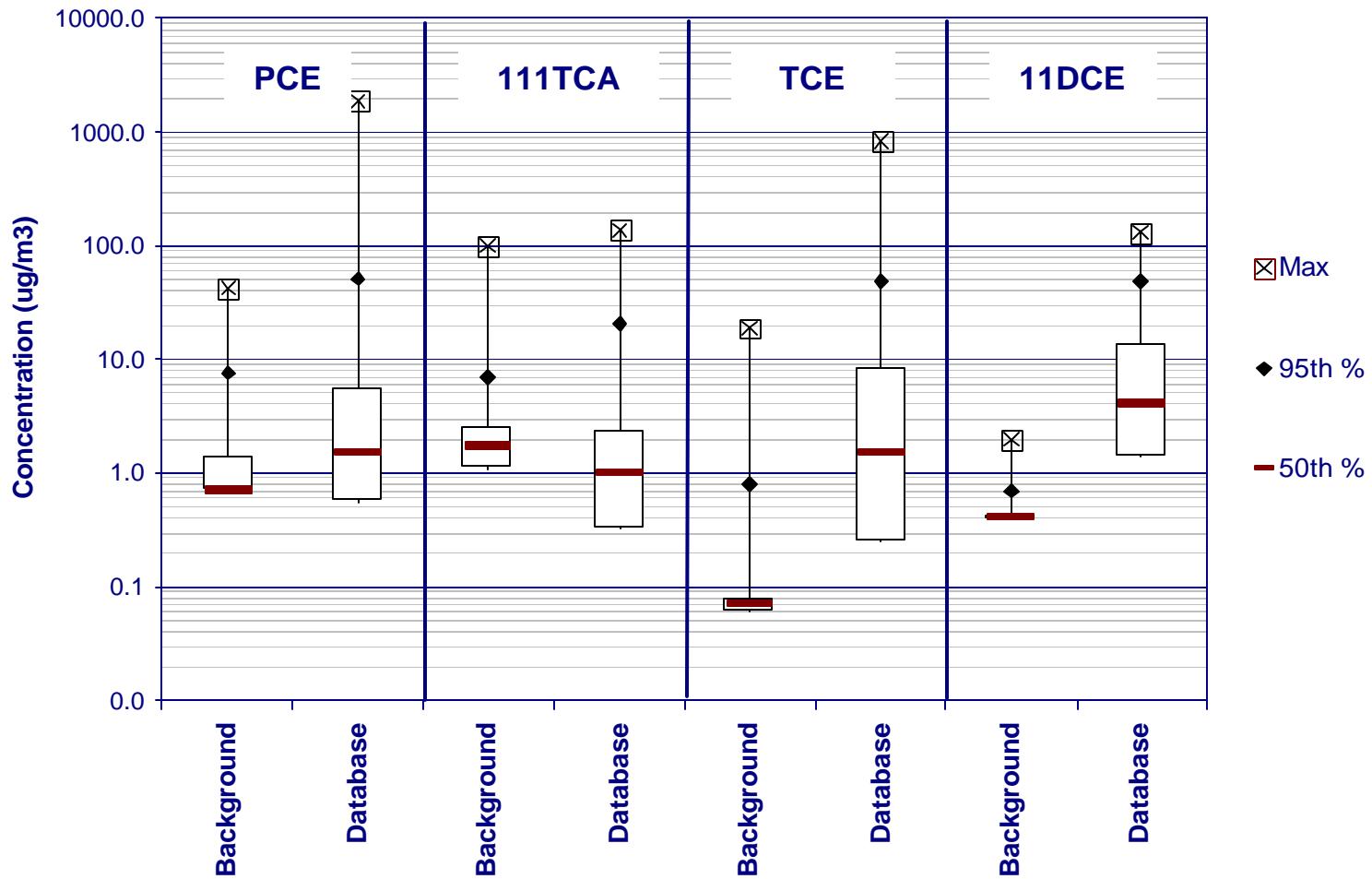
# Background



# Background

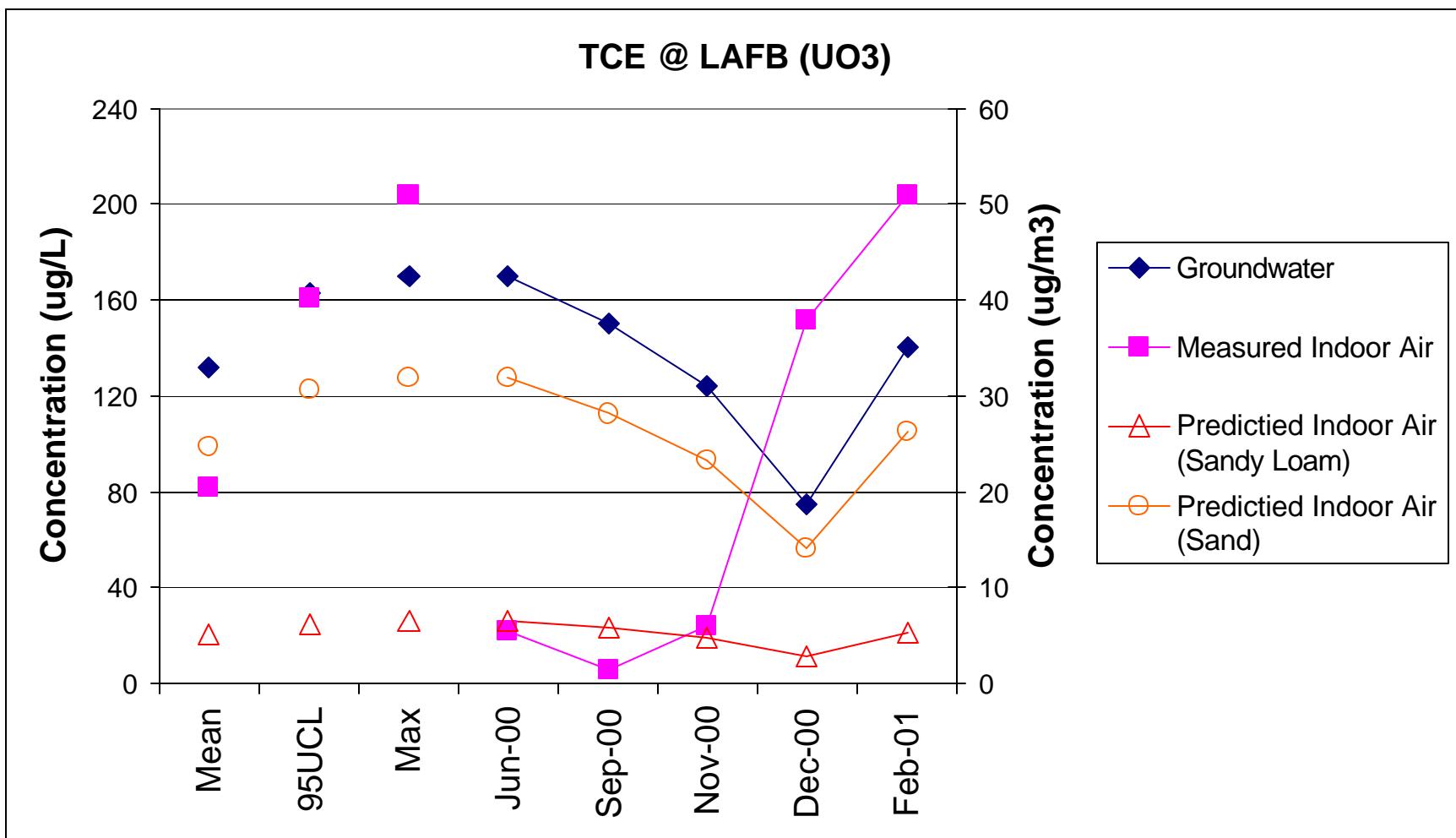


# Background Indoor Air Concentrations vs Indoor Air Concentrations at Vapor Intrusion Sites





# Temporal Variability



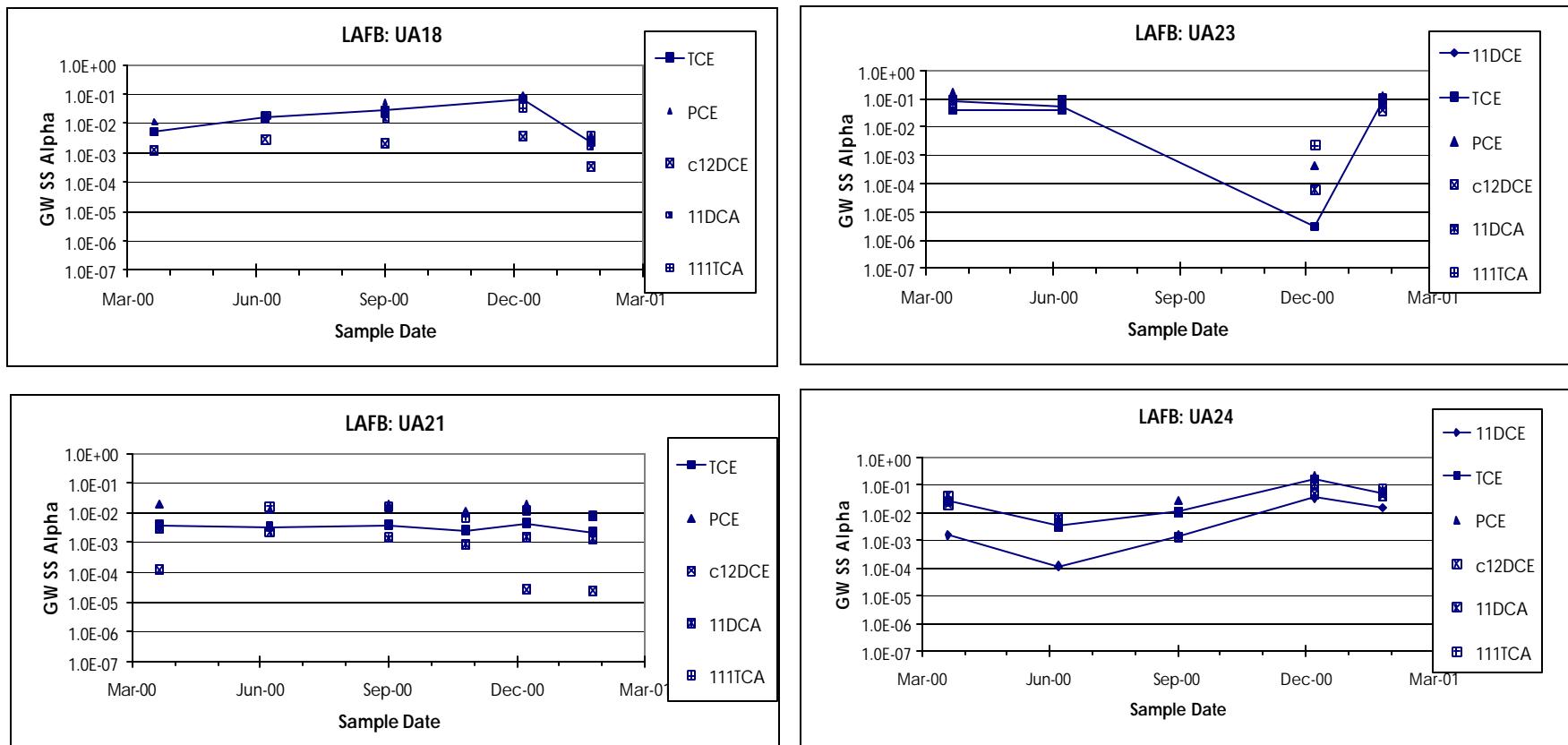


## What if modeling results based on ground-water data and soil gas data don't agree?

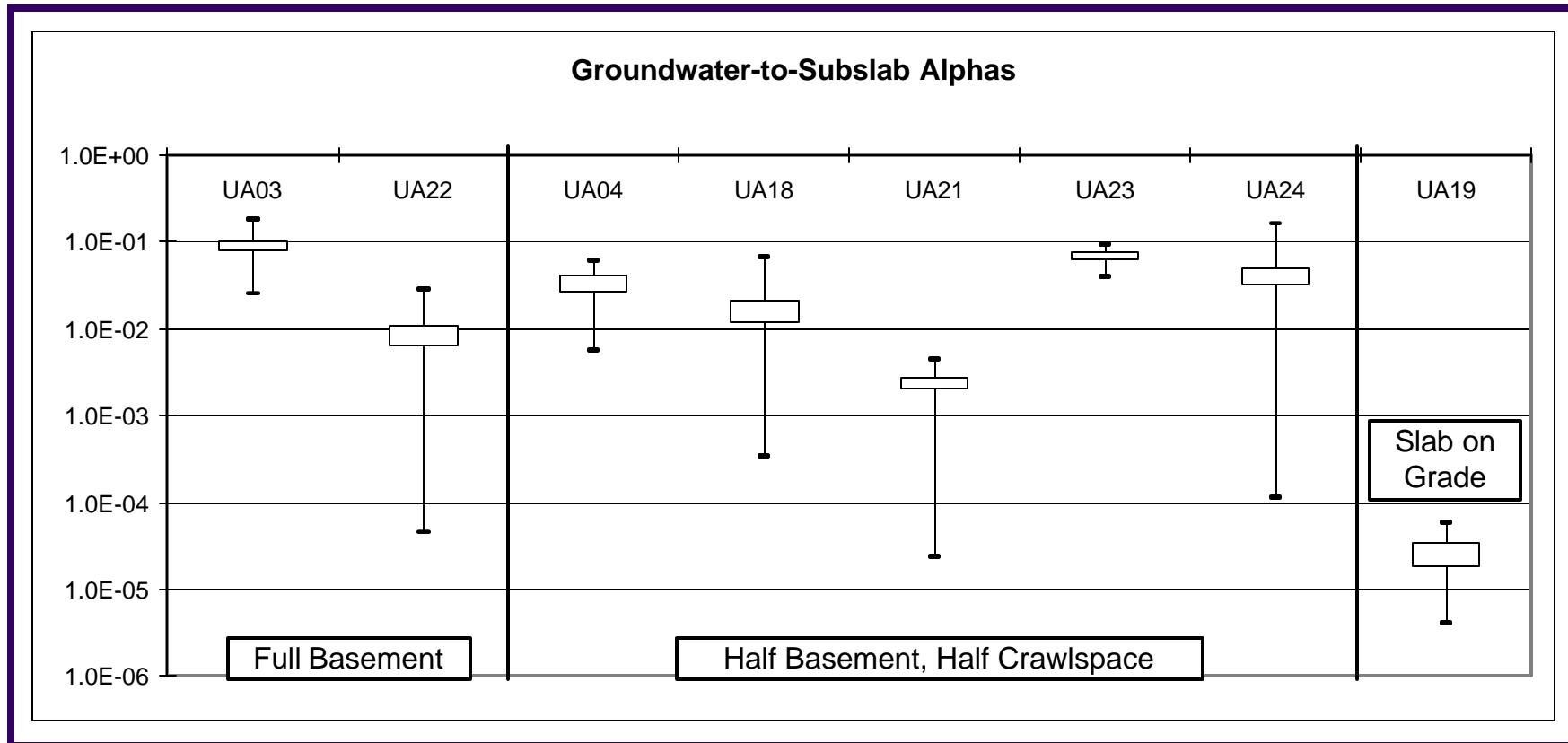
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- Geology/stratigraphy
- Sample representativeness
- Soil gas sampling considerations

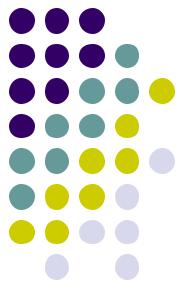
# Groundwater to Subslab Attenuation Factors



# Groundwater to Subslab Attenuation Factors



# Soil Gas Sampling Considerations

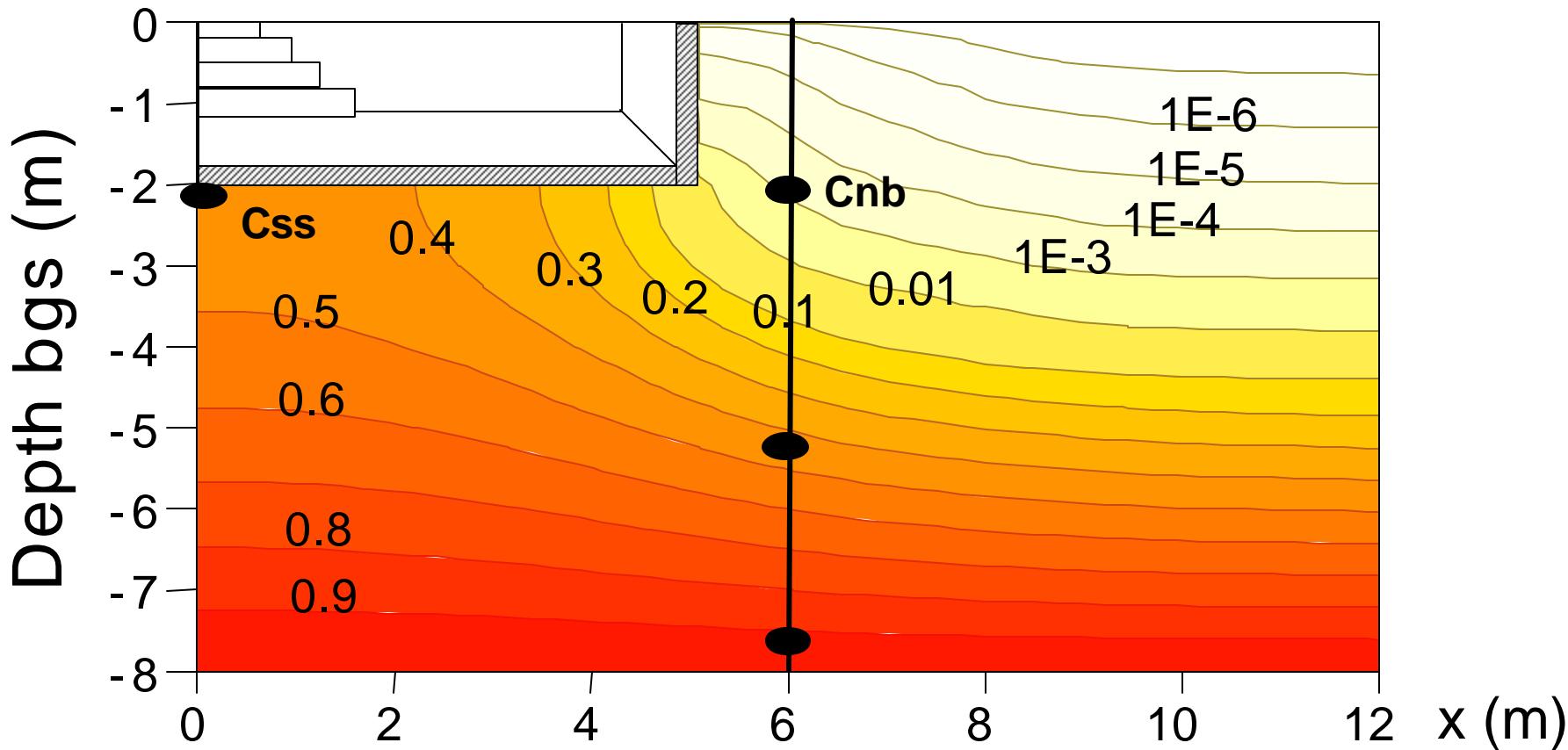


- **Soil gas:**

- Should be representative of concentrations under building.
- Near-source samples are the least variable.
- Ensure that no short-circuiting to the atmosphere occurs during sampling (seal entire annulus above the screen with a bentonite slurry or use a tracer gas to confirm the absence of leaks).
- Use vertical soil gas profiles  
(aid identification of source areas and attenuation of biodegradable contaminants like petroleum hydrocarbons).



# Soil Gas Collection Depth Issue



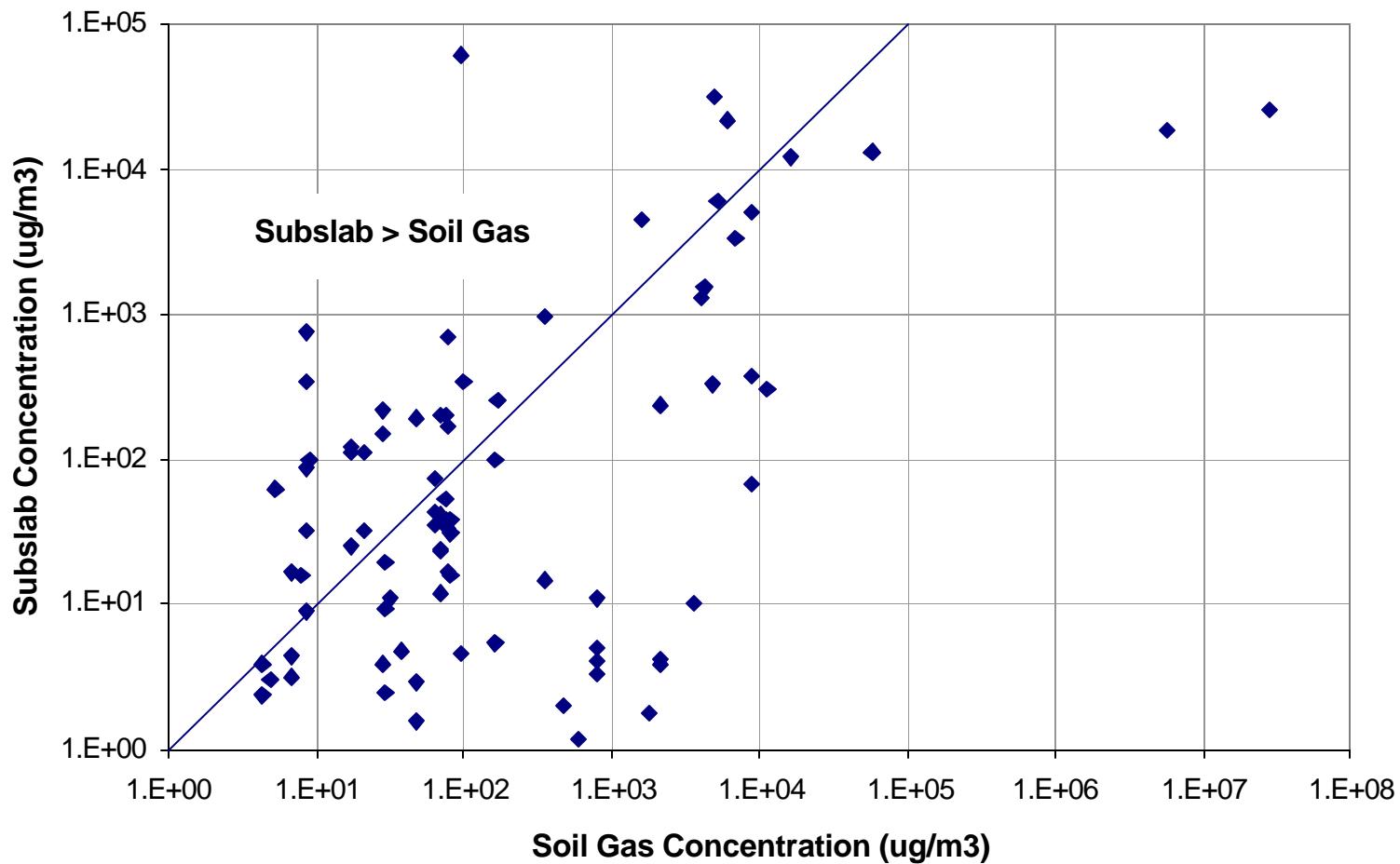
**Cnb:** near building soil gas concentration

**Css:** subslab concentration

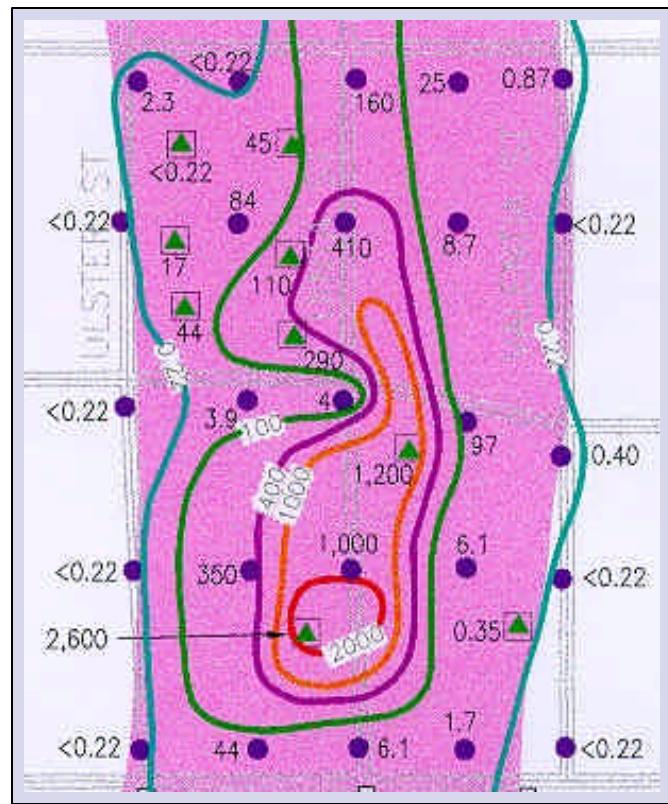
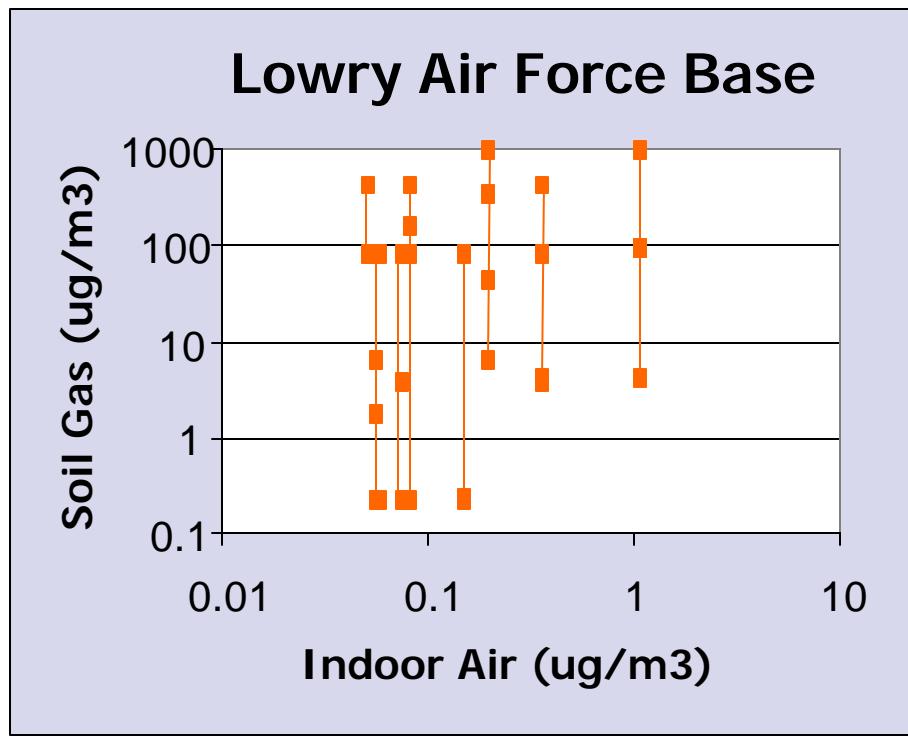
L. Abreu, 2006



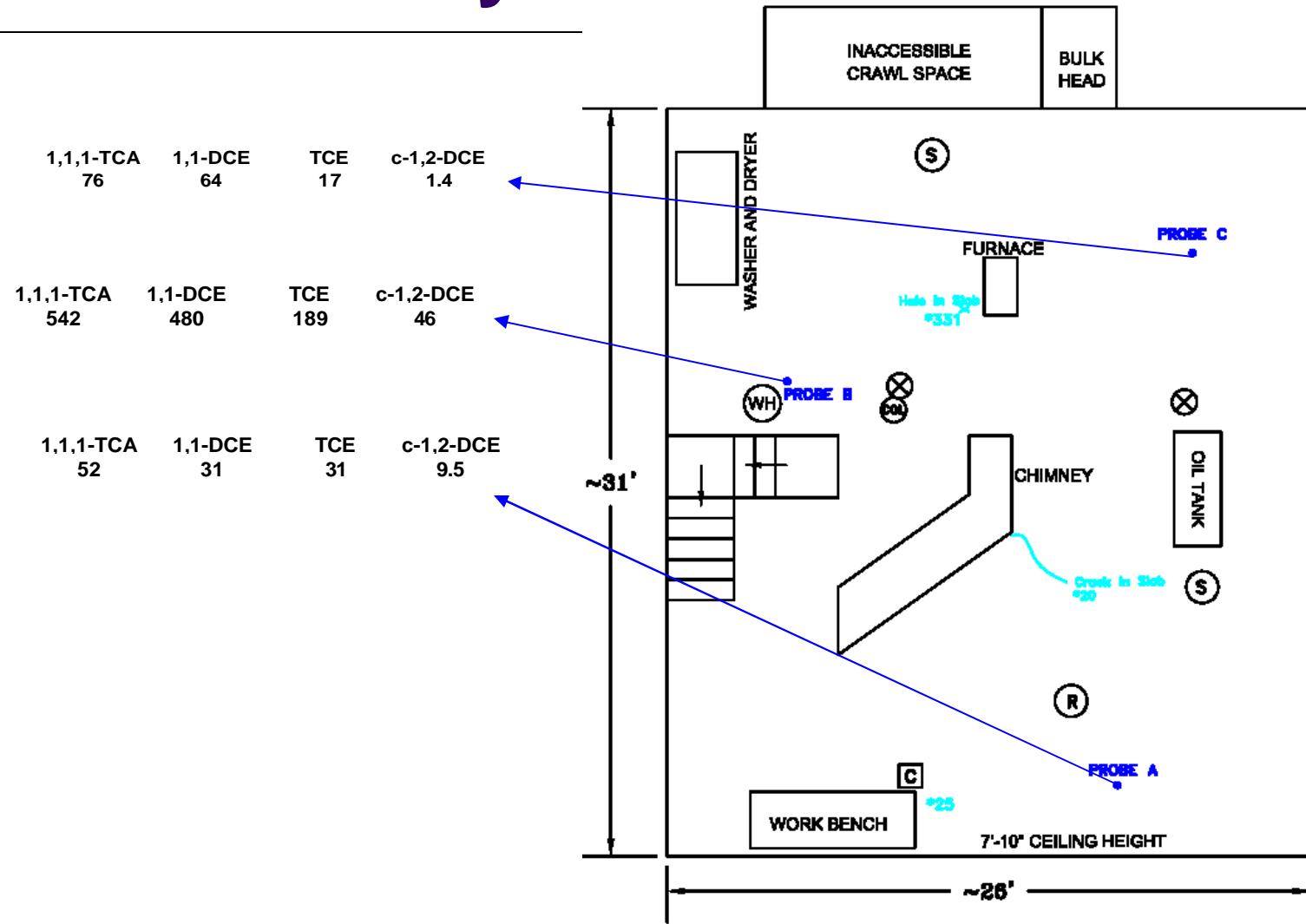
# Exterior Soil Gas vs Subslab Gas



# Soil Gas Spatial Variability



# Subslab Spatial Variability

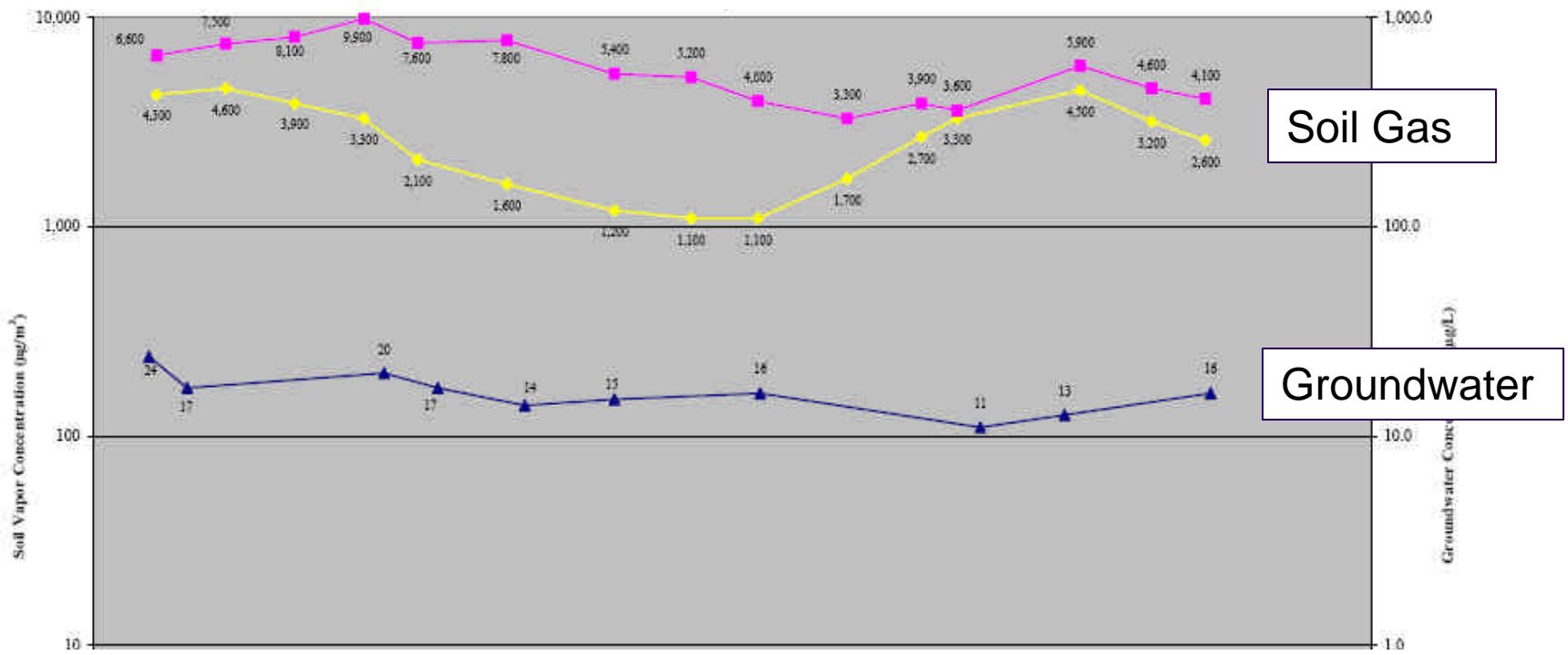


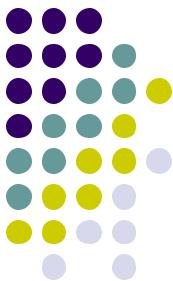
D. DiGiulio

# Soil Gas vs. Groundwater Temporal Variability



Endicott, NY

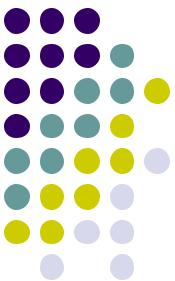




# Bulk Soil Data

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- Use to indicate presence (but not absence) of subsurface source
- Use to indicate and delineate presence of NAPLs
- Use for PCB, PAHs, e.g., semi volatiles



# Concentration Input?

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- Mean (CTE)
- 95UCL (RME)
- Frequency Distribution